

MINISTRY OF HOUSING
AND LOCAL GOVERNMENT

Manual of Principles
of Financial and Management Control
for Local Authorities
carrying out New Construction
by Direct Labour

Report by a Working Party
set up by the Minister of Housing and Local Government
in agreement with the
Local Authority Associations

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Introduction

In 1967 the District Auditors' Society produced a study by its Works Department Panel on Financial Control in Local Authority Building Departments. This study, which was subsequently published by the Institute of Municipal Treasurers and Accountants, concluded that:

'A works department is of value to a council and its ratepayers only if it is efficient and those members most strongly in favour of direct labour should be foremost in pursuit of efficient management. Given viability and efficient, cost-conscious management—working within the discipline of having to compete with contractors—the benefits of a works department to the council, its ratepayers and its tenants can be very considerable'.

Following consultations about the study with the local authority associations and the main professional and building industry trade associations the Minister in agreement with the local authority associations set up the present Working Party in May 1968, with the following terms of reference:

'To consider problems of financial and management control in local authority direct labour departments having regard to the study made by the District Auditors' Society on "Financial control in local authority building departments" and to draw up, for consideration by the Minister of Housing and Local Government and the local authority associations, a short manual of principles on these matters for the guidance of authorities carrying out new construction by direct labour'.

The composition of the Working Party was given in a Written Answer in Parliament on 17th December 1968 as follows:

Nominated by the Minister of Housing and Local Government

Mr. R. Lloyd Thomas*, Assistant Secretary, Ministry of Housing and Local Government (*Chairman*)

Mr. P. Kitchen, Higher Executive Officer, Ministry of Housing and Local Government (*Secretary*)

Nominated by the Association of Municipal Corporations

Mr. L. Berry, A.R.I.B.A., A.I.A.S., Borough Architect, Gateshead County Borough Council.

Mr. H. G. Echart, F.C.A., F.I.M.T.A., Borough Treasurer (retired), Lambeth London Borough Council.

Mr. H. Smith, O.B.E., F.R.I.C.S., General Manager, Public Works Department, Sheffield County Borough Council.

Nominated by the Urban District Councils Association

Mr. J. Quinn, B.Com., D.P.A., Clerk, Consett Urban District Council.

*Replaced Mr. W. O. Ulrich in September, 1968.

Nominated by the Greater London Council

Mr. E. Hodgkinson, F.R.I.C.S., Senior Quantity Surveyor, Greater London Council.

Nominated by the Rural District Councils Association

Mr. F. Bowman, A.R.I.B.A., Architect, Chester-le-Street Rural District Council.

Nominated by the Chief Inspector of Audit

Mr. S. T. Evans, Barrister-at-Law, District Auditor, Metropolitan District.

All the local authorities mentioned have direct labour departments carrying out new construction.

We have had 5 formal meetings supplemented by other informal meetings between members. We have sought advice from the main professional and trade associations and the building trade unions and we acknowledge with thanks the contributions made by those bodies listed below either in response to our invitation or at the invitation of the Ministry following the production of the District Auditors' Society's Study. We are also grateful to the National Building Agency for the advice it has given on the techniques of programming (reproduced in Appendix II). We are above all grateful to the District Auditors' Society for its Study which was an invaluable starting point for our discussions.

It may be appropriate to say a few words about our approach to the preparation of this manual. We agreed early on in our proceedings that our terms of reference did not permit us to argue the case for or against direct labour. We have accepted that local authorities have the right to use direct labour for new construction and that many of them do so. We have also accepted that there are advantages and disadvantages to both the local authority and direct labour department by virtue of the special relationship between them, but we do not consider it appropriate to restate or discuss them here. It has been suggested to us that there is a case for legislation to enable a direct labour department to operate as a trading service. This is an interesting suggestion and one that may merit further investigation but it is not within our terms of reference and we have not examined it.

We have taken due note of the instances of successes and failures by direct labour departments which were brought to our notice but only with a view to learning from them what factors tended to promote or militate against the efficient working of the department. We have seen our task as not to sit in judgement on direct labour but simply to offer guidance on how a local authority might use its direct labour department efficiently and with the maximum benefit to its ratepayers and tenants. Since this is intended to be essentially a working manual we have not gone into any great detail or explanation but have confined ourselves to the setting up of basic principles. In Appendix I we also show by way of example instances of methods and procedures which have proved successful in practice; we are grateful for permission to publish this material although we have not identified the sources.

Finally we wish to place on record our high appreciation of the services of our Secretary, Mr. Kitchen. He has been indefatigable in assembling material

for our consideration and skilful in his contribution to the drafting of the manual. We are all much indebted to him.

With this brief preamble we present our manual for consideration by the Minister and the Local Authority Associations.

R. LLOYD THOMAS

L. BERRY

F. BOWMAN

H. G. ECHART

S. T. EVANS

E. HODGKINSON

J. QUINN

H. SMITH

P. KITCHEN (*Secretary*)

March, 1969

List of bodies submitting written evidence

The Institution of Municipal Engineers

The Institute of Municipal Treasurers and Accountants

The Institute of Housing Managers

The National Federation of Building Trades Employers

The National Union of Building Trades Workers

The Committee of Associations of Specialist Engineering Contractors

The Federation of Associations of Specialists and Sub-contractors

The Institute of Municipal Building Management

The National Building Agency

MANUAL OF PRINCIPLES

The Role of the Committee

1.1 The Committee of the local authority responsible for the Building Department must lay down broad lines of policy for the operation of the Department.

1.2 The main aim to which all policy must be directed is that taken year by year the Building Department should produce a financial saving to the authority as against having work done by contractors.

1.3 The Committee must, therefore, require the local authority's Treasurer to provide annual financial statements showing the results of the Building Department's operations (see para. 5.2) and the final accounts for completed projects (para. 6.6). The Committee should also be kept informed of the progress of the Building Department on current contracts in terms of expenditure incurred against the value of work done. This may be done at quarterly intervals, but we should expect larger authorities to be able to operate on the basis of management by exception so that reports need be made to the Committee only when the periodic cost/value comparisons reveal an unsatisfactory situation. In interpreting this it should of course be borne in mind that although an adverse cost/value comparison is often a useful warning light it may also, particularly early in a contract, be due to no more than a high—and expected—expenditure on preliminaries.

1.4 The Committee should pay close attention to the final accounts which it receives to determine, in the light of advice from its officers, any action which may be needed in respect of the future operations of the Building Department and also to take such information into account when considering the ability of the Building Department to carry out further schemes.

1.5 On receipt of the annual financial statement prepared by the Treasurer the Committee should review the performance of the Building Department and consider whether the savings* realised justify the continued operation of the Department on existing policy lines or whether any changes might be advisable. It must be realised that if over a period of time the Department merely breaks even against contractors' prices or produces only marginal savings this normally means that the Department is using more real resources in carrying out the work and is, therefore, relatively less efficient. This loss of real resources can be considerable, and, since both Building Department and contractor would spend about the same on materials, sub-contracts etc., would be largely attributable to inefficient or expensive use of labour.

1.6 For effective comparisons to be made with contractors' tenders the Building Department should be required to compete for a considerable and representative proportion of its work subject to similar contractual conditions (see para. 4.2) as a contractor would have to comply with. The Department should however be permitted the same facilities as would be given to a contractor for negotiating for further work on the successful outcome of recent similar schemes, and taking into account the Department's performance on current schemes.

*See para. 5.2 and Appendix III.

1.7 In view of the importance of schemes being completed to time—delays mean extra costs, and there is no return on expenditure until a house has been handed over to its tenant—a monthly progress report should be made to the Committee. On the conclusion of schemes, estimated and actual building periods should also be reported to the committee.

1.8 Continuity of work is as important to the Building Department as to any other contracting organisation. The Council can help in this by planning for a minimum level of work to be given to the Department whether in competition or by negotiation, subject to its quoting acceptable prices. The factors determining this decision would normally be:—

- (a) the capacity of the Department, in terms of management staff, permanently employed workers and plant,
- (b) the recent experience of the Department and its senior staff on work of a similar class and scale and involving similar management and operative skills and techniques of construction,
- (c) the performance of the Department on recent projects in terms of cost and completion to programme.

If continuity is to be reconciled with competition the proportion of work expected to go to the Department must be substantially less than the whole. It is highly undesirable that the future of the Department or of its workers should hang on its winning any particular contract since this may lead to unrealistic estimating and consequent overspending. The aim should be to ensure a continuity of the sort of work which the Building Department has shown it can do most efficiently.

1.9 The Building Department should not be permitted to overstretch its resources by taking on work for which it is inadequately equipped. The Committee should, therefore, limit the Department's rate of expansion and the size of job which the Department may undertake. We cannot lay down limits to apply in all cases, but it has been suggested to us that in general circumstances the maximum rate of expansion should not be more than 25% over the average turnover for the previous two years, and also that no single scheme should form more than six months' turnover based on the average of the previous two years. Discretion must of course be used in applying such rules where Departments build very few houses each year. There may also be well established Building Departments which have the resources to tackle individual large contracts.

1.10 The Building Manager should be allowed to run the Building Department within the broad lines laid down by the Committee and without intervention by the Committee or any of its members in the day to day administration of the Department. Such intervention is contrary to the functions of local government committees as recommended by the Maud Report and makes it more difficult for the Committee to discharge its duties; it is also bad for morale and blurs the Building Manager's responsibilities.

1.11 The Committee should at all times be aware of the dangers of allowing its own political leanings to determine the nature of its policy decisions. The Building Department will serve its authority best if it is encouraged and allowed to operate as an efficient building contractor with a minimum of favours and

disabilities imposed on it. Serious difficulties can arise if doctrinaire opinions lead committees or members to defend direct labour uncritically as a desirable end in itself or on the other hand undermine the Department's viability by imposing undue restrictions on its operations e.g. by requiring it to obtain all its work in competition with contractors and/or by unduly restricting the size of scheme for which it may tender.

Organisation and Management

2.1 Where the size of the local authority permits, the Building Department should be established as a separate organisation under its own Chief Officer (referred to in the manual as the Building Manager) who will be responsible to the Council through the appropriate Committee. Even where there is no separate Building Department there should be an officer designated as, and having the responsibilities of, the Building Manager.

2.2 If the Building Manager is to run his Department efficiently he will need a flexible labour force and must, therefore, have power to recruit and dismiss workers as the need arises. In some Departments this is made easier because of the high proportion of casual labour, but problems can still arise in keeping together the nucleus of technical and advisory staff which is essential in building management. This is a problem common to the whole building industry, however, and we consider that the proposal for assessing the results of a Building Department over a reasonable period of time and not in relation to one specific scheme should give efficient Building Managers the flexibility they need to retain their key staff. There are clearly advantages—both operationally and as a matter of morale—in maintaining a reasonably stable labour force. Effective forward planning can do much to provide such stability by helping to ensure continuity of work and an even rate of building.

2.3 The Building Department should have its own technical and administrative staff. Its accounting and costing work should be carried out by the Treasurer's Department in order both to avoid duplication of work and to ensure that the Building Department's accounts are seen to be independent. Close collaboration between the Treasurer's Department and the Building Department will be necessary to determine what cost statements and data are needed, the arrangements for their production and their form and content. The Building Department should see all cost documentation first in order to check and code it; the Building Department will of course need to have staff for this purpose and to extract from the statements supplied by the Treasurer the information needed for each level of management in the Building Department.

2.4 In its relations with the other Departments of the local authority the Building Department should be regarded as nearly as possible as a contractor e.g. although the Treasurer's Department should provide an accounting and costing service on lines agreed with the Building Department the cost of this service should be borne by the Building Department. It follows from this that the Building Department must be accorded the same facilities from other departments of the local authority as would be available to a contractor.

2.5 It cannot be too strongly emphasised that the success of a Building Department depends on the quality of its management at all levels.

2.6 Within the Department there should be a clear line of succession so that the absence of a senior officer does not throw the Department out of gear. This does not mean that all vacancies must be filled from within the Department; local authorities should continue to look for the best man for the job.

2.7 It must be recognised that good staff will not be attracted to a Department or stay there without an adequate salary structure. As the cost of this must be borne as overheads in the contracts which the Department carries out there must be real doubts whether a Department with a workload of much less than 100 houses per annum can afford staff of the quality needed to ensure its efficient running; this must, however, be considered in the light of local circumstances. Some of the smallest Departments owe their success to the personal drive and initiative of a single responsible officer, but this is not a pattern of organisation which we can recommend and it is one which may become irrelevant in a revised local government system based on fewer and larger units. The scale of operations of a Department will dictate the qualitative and quantitative needs of management and these ought to be met. It is imperative that management should understand and apply modern programming and costing techniques.

2.8 All Building Departments must recognise the necessity for proper training of all management and supervisory staff and should play their part in training apprentices.

2.9 We cannot in a short space do more than refer to the part which work study can play in the building industry. Its importance in incentive bonus schemes is well known; indeed all new incentive schemes in local government must be based on method study and work measurement by qualified people. But we should also like to see Building Departments looking further into the benefits which work study can offer in the way of feeding information to estimators, evaluating alternative methods of operations, providing basic data for pre-planning of contracts and assisting site management. We think these benefits could be considerable.

2.10 Where Building Departments have separate manufacturing departments, e.g. joinery shops, these should be costed separately and should submit detailed estimates for all the work they are asked to do. Their costs should periodically be checked against competitive quotations obtained from outside contractors.

Planning

3.1 The Building Department should continually review its future needs in the way of permanently employed workers, plant and materials in the light of the likely work load ahead and should make broad plans for meeting these needs, by an analysis where possible of the circumstances of each potential site. It would greatly help this forward planning if the Committee had previously provisionally planned for a proportion of the Council's work to be given to the Department, subject always to the Department's prices being competitive and to the considerations suggested in paras. 1.8 and 1.9.

3.2 The Department should also ensure that each building scheme is properly programmed. A detailed construction programme is essential for the efficient organisation of any project and should be prepared in sufficient detail for full advance consideration to be given to the timing and duration of all site activities, material and plant delivery dates, labour schedules, and dates for sub-contractors' and specialists' activities on site. The construction programme must be capable of highlighting potential difficulties and problems and of helping to identify the most economic methods of construction consistent with safety and local circumstances.

3.3 More detailed short-term working programmes should be prepared for use on the site. These should set out the sequence and times of operations for periods of about 4 to 5 weeks in advance and cover gang sizes, short term material and plant requirements etc. Weekly trade programmes and schedules showing target completion dates for specific operations may also be considered.

3.4 The choice of programming techniques and the extent to which they are used must depend on the size and complexity of the scheme and on the calibre of the staff who have to operate it. The plan must be clear but flexible; if it is too detailed it may stifle the initiative which is so necessary in site management. The employment of a specialist planner may often be desirable as site management will inevitably be pre-occupied with the solution of day to day problems and may not be able to spare the time needed for planning.

3.5 Advice on some of the techniques of programming which are available has been contributed by the National Building Agency and is reproduced in Appendix II.

3.6 As the size and complexity of building schemes increase network analysis is likely to grow in importance. It is, however, expensive and should be used only where the cost can be justified. Its value is greatest in large, complex "one-off" jobs; on repetitive jobs (e.g. housing schemes, including multi-storey housing) the line of balance method may give better value for money. Factors to be considered in deciding whether to use network analysis include the following:

- (a) how flexible is the sequence of operations? The greater the choice of sequence the less is the need for network analysis.
- (b) to what extent is progress governed by a few key resources (both labour and plant) which must be kept continually employed if the scheme is to be financially successful? If it is very largely governed in this way there is little case for network analysis.
- (c) how much of the work is repetitive? If the scheme is largely repetitive the planning should concentrate on method and work study to improve the cycle rather than on elaborate networks.

3.7 When network analysis is used it is important that:

- (a) the information on which the network is to be based is, within reasonable limits, accurate and complete; in particular that essential drawings are available (and will not drastically change) and that the bill of quantities is complete and informative.

- (b) the network should be kept up-to-date. Where the network is computerised the monthly updating can be done easily and economically and the impact of changes on the plan as a whole becomes known quickly.
- (c) the network planning documents should be prepared in a form which is easily intelligible to the level of management for which they are intended; this is particularly important when using computerised critical path networks.

Tendering for Work

4.1 The Building Department should be required to tender in competition with contractors for a considerable and representative proportion by value of its work as a test of the efficiency of the organisation. The Department should, however, not be denied the opportunity of negotiating for further similar work on the successful outcome of previous competitive schemes provided that the same basis of pricing is retained and that any increases in costs are certified as reasonable by the council's architect.

4.2 The Building Department should observe the same tendering procedures and assume similar obligations to a contractor. In particular the Department must be subject to the same specification requirements and supervisory conditions in the way of architectural supervision and clerk of works' inspection; it is essential that these responsibilities of the architect be respected by both the Building Department and the Committee.

4.3 We expect that all schemes other than the smallest will be tendered for on a priced bill of quantities. Lump sum pricing should be avoided. The pricing of bills should follow careful analysis of the project and should take account of feedback of information from current jobs reinforced wherever possible by work study. The rates in the bills should be broken down in such a way that ready comparison of costs against estimate can be made for labour, materials, plant and overheads. Techniques of estimating vary but where the Preliminaries Bill covers items such as materials distribution, unproductive time, overtime, operational and administrative expenses, labour, plant, stores oncosts, etc., these should all be analysed and priced according to the nature of the work to which they apply. A comprehensive costing system should be initiated to allow ready comparison with the estimate.

4.4 It is particularly important for a Building Department to ensure that its estimate and final account include all indirect charges—labour and materials oncosts, Building Department overheads and central administrative expenses—which are properly chargeable to a scheme.* Wherever possible direct apportionment of these charges is to be preferred and—for all except central administrative expenses—separate oncost accounts should be run for construction and maintenance work. Where an indirect apportionment is made the percentages used should be reviewed frequently. The Building Department's overheads should include the costs of unsuccessful tendering.

*See definitions in Appendix III.

4.5 Bonus targets should be set well within the labour element in the bill rates to provide a margin for contingencies; they should be based on work study or other sources of information and not merely be derived from the bill rates.

4.6 Sub-contracts whether for labour only or for labour and materials ought to be let under competitive conditions as to price, time and quality and be subject to contractual conditions similar to those in the R.I.B.A. form of sub-contract.

4.7 The estimating of costs attributable to mechanical and non-mechanical equipment must take account of the way in which the Department will cost different types of equipment which have varying lives and therefore different rates of depreciation. (see also paras. 7.5 1-5).

4.8 For small schemes where only a comprehensive specification is used for tendering purposes the Building Department (like any contractor tendering) should be prepared to submit a detailed build-up of the tender price so that adjustments can be made to take account of any subsequent changes which may be made in the scheme.

Overall Financial Control

5.1 It has been suggested that Building Departments should follow the example of contractors in including a certain percentage for profit in their estimates. We doubt whether any advantage would be gained by this. A contractor includes a profit element in his price because profits are necessary to ensure his continuance in business. The Building Department does not operate in this way. Its clients, the local authority committees, will pay only the actual costs incurred on their contracts. It seems to us absurd, therefore, to require a Building Department to quote a price of $fx + y\%$ for a job in the knowledge that if it is completed to the estimate the client Committee will pay only fx . It is also arguable that the inclusion of a profit element might even prove a disincentive since, in the knowledge that it is only a paper figure, it might be used as a cushion to absorb increased costs.

5.2 Nevertheless the profit element cannot be ignored; as stated in para. 1.5 a Building Department which over a period only breaks even with contractors is using more in real resources because the contractor's price includes his profit. The following course is therefore recommended as a check on the Department's profitability:

- (a) that the Treasurer should keep a record showing (i) the saving or loss made by the Building Department on each scheme, i.e. the difference between the costs incurred by the Department as compared with what would have been payable to the lowest tendering contractor, and (ii) the saving or loss made by the Building Department in each financial year (including the results of schemes in progress which will be available from the interim cost/value comparisons);
- (b) that these savings or losses should be reported by the Treasurer to the Works Committee and to the Finance Committee, along with the Building Manager's comments on them; and

(c) that such reports should also state the amount of the savings or losses as a percentage of the cost of the parts of the schemes for which the Building Department was wholly responsible, i.e. excluding nominated sub-contractors' work.

5.3 Arrangements on these lines will make for more effective use of real resources and increase the value of competitive tendering as a guide to the efficiency of the Department; they are essential if the Committee is to have adequate information to enable it to review the performance and financial results of the Department over a period.

5.4 Where the Department has undertaken a scheme on a negotiated tender the saving or loss can be assessed by reference to the saving or loss on the competitive scheme which was used as the basis for the negotiated tender (subject to any observations by the quantity surveyor responsible to the council's architect for negotiating the price).

5.5 The Building Department cannot regard savings which it makes as available, for example, to offset losses which might result from other contracts. It is recognised that this deprives the Department of a flexibility of operations which a contractor enjoys but to allow it to the Building Department would defeat the main purpose of the proposed arrangements i.e. to ensure optimum use of the limited real resources available for building.

5.6 A contractor has to finance the cost of his operations pending the receipt from his client of payments on account. It seems reasonable that Building Departments should bear a similar responsibility. We suggest that the Treasurer should keep a simple memorandum record showing the payments (including salaries and administrative expenses) made on behalf of the Building Department and, on the other hand, amounts "payable" to the Department under interim cost/value statements. The amount chargeable to the Building Department would be the difference between these two amounts multiplied by the appropriate short term interest rate. The amounts "payable" to the Building Department should not be regarded as accruing to the Department at the date of the valuation, but only after such a period as it would have taken the Treasurer to make a similar interim payment to a contractor.

NOTE: for definitions of "savings" and "losses" see appendix III.

Contract financial control; interim and final cost/value comparisons

6.1 During the currency of a contract the basis of financial control is the periodic comparison of costs incurred by the Building Department against the value of the work done to date—referred to in this manual as a cost/value comparison.

6.2 The costs part of the cost/value comparison should be prepared by the Treasurer who, as recommended in para. 2.3, should be responsible for all the accounting work of the Department and for the production of all necessary financial statements. His classification of expenditure should take account of the classification used by the estimator. In preparing the statement the

Treasurer will have to work to a strict timetable and may find it necessary to estimate certain costs. The simplest method of dealing with materials costs is to charge the materials to the scheme on the basis of priced goods received sheets, making any necessary adjustments when the invoices are paid.

6.3 The valuation part of the cost/value comparison should be prepared by a quantity surveyor, either from the Architect's Department or outside, but who in any case is independent of the Building Department. He should take account of the method of pricing used in the bill of quantities. He should wherever possible agree his valuation with the quantity surveyor of the Building Department but it must be emphasised that the independent quantity surveyor and ultimately the architect must accept responsibility for the valuation.

6.4 The importance of the interim valuation as a cost control suggests that an accuracy of $\pm 5\%$ might not be sufficient on largely repetitive work and we recommend that an accuracy of $\pm 2\frac{1}{2}\%$ should be the aim. We recognise that an accuracy of this order will be more expensive to achieve and would suggest that such valuations be made at three monthly intervals, with monthly valuations to a lower degree of accuracy, unless the Building Manager specifically requires a more accurate valuation for the whole or part of the contract.

6.5 The interim cost/value comparison is essentially a head office financial control. It is vital that site management should have similar, although less sophisticated, records to compare output with costs. The methods used may vary. The records may be in physical terms, by amounts of materials used and time spent by gangs. But it will usually be advisable for the site agent to keep a book which records, by gangs, the cost of work done each week and, as a comparison, the value of the work; such a record should also include bonussing.

6.6 A final statement of account based on the tender should be submitted to the Committee within, say, nine months of the completion of a scheme even if some costs have to be estimated. This should clearly show the underspending or overspending and the profit or loss for the scheme, without adjustment for increased labour and material costs except insofar as the Department is entitled to such an adjustment. The report should also identify the savings or loss on the work which the Department has itself carried out, distinguishing nominated sub-contractors' work.

6.7 To ensure comparability of the final cost and statement of final account all alterations to the specification of the work must have been covered by the architect's variation orders and priced in the final account and agreed in the normal manner, as they would be in a final account agreed with a contractor. Any claims made by the Building Department because of extra expenditure on preliminaries or other circumstances beyond its control must be considered by the architect as if they had been made by a contractor.

Contract financial controls

arrangements for main elements

7.1 Although the interim cost/value comparisons are essential as an indication of the overall efficiency of the Building Department in keeping to its estimate

the results are largely dependent on the cost control arrangements for the different elements. These elements are:

- (a) labour
- (b) materials
- (c) plant
- (d) sub-contractors
- (e) oncost and administrative expenses.

They all pose different problems which require their own methods of control and it is necessary to consider each element separately.

7.2 All cost control procedures must be related to the size of the project, the resources of the Building Department and the local authority, and the needs and abilities of those using them if they are to operate effectively and at a reasonable cost. The principles outlined in the following sections are basic ones which would apply to all Building Departments but they may have to be refined and developed further by the largest Departments because of the scope and complexity of their operations. More and more Departments will be able to make use of computers. Comparison of costs incurred in the different operations must be related to the basic document on which the tender is prepared, "the bill of quantities". Most bills are produced in accordance with the Standard Method of Measurement of Building Works which aims at a description of the completed works summarised by trades. Whilst this serves as a basis for estimating and post-contract technical accounting it does not attempt to reproduce the processes by which the actual production cost of the building will be incurred in practice. We are aware that experimental work is taking place to overcome this difficulty and a system of "operational Billing" has been developed wherein instead of presenting the work by trades the construction work is described as a series of operations and estimates for labour, materials and plant are kept segregated. In view of the fact that this segregation of costs by operations is most closely related to the costing of work as it proceeds we advise Building Departments to give serious consideration to developments on these lines as an aid to more accurate control of costs. It may well be that for ease of estimating the traditional method of preparation is the best but due consideration should be given to supplementing this method by those latterly described as an extra tool of management. At the very least segregation of descriptions into labour, materials, and plant content must, we consider, be an aid to comparison with actual costs for whole units of completed work.

7.3 Labour

7.3.1 Labour costs control operates at several levels

- (a) weekly trade programme,
- (b) weekly reviews of bonus payments, unproductive time and non-bonus work,
- (c) management's comparison of actual with estimated performance,
- (d) control of overtime,
- (e) periodical comparison of the labour element of output with labour cost to date.

7.3.2 The importance of general managerial skills in site organisation cannot be over-emphasised. One of the major problems of effective site management is to keep unproductive time to a minimum. Each building manager, contract manager or site agent will have his own ideas on this, depending largely on the type of work, and some will rely mainly on personal supervision and drive. This approach may be very effective within smaller Departments and on small schemes but has its limitations. All site management staff must be aware of the importance of the short term working programmes and the weekly trade programmes, and the need to ensure that these are operated effectively.

7.3.3 A well-devised and well-administered incentive bonus scheme provides a large measure of control on labour costs. Each man has a vested interest in the efficient organisation and management of the site since unproductive time represents lost opportunities to earn bonus. If the incentive bonus targets have been properly set the labour element in the estimate should not be over-spent provided:

- (a) all the men are earning bonus;
- (b) the amount of unproductive time is not in excess of the level assumed by the estimator in pricing the bill; and
- (c) the expenditure on non-targeted work does not exceed that envisaged when the estimate was prepared. It is important that bonus targets should be established for practically all operations. A certain amount of non-targeted work is inevitable but this should be kept to a minimum. It may be necessary for site management to issue "spot" targets for work which is outside the normal schedule of bonus targets but the quantity and quality of such "spot" targets must be kept under close control by the senior management.
- (d) the scheme is being applied properly—e.g. accurate measurement of work done, etc.
- (e) the work targeted and measured is inspected as properly carried out before bonus is paid.

It is essential, therefore, that there should be a weekly return of men not earning bonus, unproductive time (in detail, with reasons) and non-targeted work. This should be produced promptly so that it is available for use by the site agent and contracts manager within a day or two of the end of the week.

7.3.4 If actual progress is recorded on the construction programme, the contracts manager and site agent are better informed about cases where production has varied appreciably from the expected standards. This not only helps them to isolate and deal with organisational defects, e.g. unproductive time, waiting for materials, unbalanced gangs, but also enables the site agent or planning staff to prepare the next working programme on a more realistic basis.

7.3.5 The working of overtime other than casual overtime should be kept under strict control and should require the personal sanction of the Building Manager. This should be regarded as a management decision of first importance.

7.3.6 Labour costs are usually analysed by trades because analysis by operation has the disadvantages that:

- (a) it calls for great care in the analysis of men's time; and
- (b) the results cannot normally be compared easily with the labour element in the estimate, since the bill of quantities is usually prepared on a trade basis, not on an operational basis.

Whatever method of analysis is adopted, there should be periodical comparison of the value of output with the cost to date. This is normally done on total cost but, because of the paramount importance of controlling labour costs, there is considerable advantage in making periodical comparisons of the labour element in the output with the labour cost to date—in total or, preferably, by trades.

7.3.6 Accurate completion of time sheets is essential. This is more likely to be achieved if all time sheets are entered and handed into the site office at the end of each day.

7.4 Materials

7.4.1 The purchase of materials is governed by standing orders. These are not always appropriate to the needs of a Building Department and the local authority should consider whether they should be modified in order to allow the Building Department more flexibility in its purchasing arrangements. One course to be recommended is to have separate standing orders for the Building Department, based on the practical needs of the Department but having regard to the need for public accountability. Such standing orders might include the following stipulations:

- (a) a minimum of 4 quotations to be obtained where possible for materials and sub-contracts,
- (b) approved lists of suppliers and sub-contractors to be kept and continually revised in the light of experience,
- (c) the persons authorised to order materials and services to be specified along with the delimitations of their authority, including their power to negotiate with tenderers.

The standing orders should be flexible enough to allow the Building Department to buy materials in an emergency with only subsequent covering authority, take advantage of special market circumstances, negotiate long term contracts with suppliers (possibly in consortium bulk ordering schemes) and negotiate reductions in prices where this seems appropriate.

7.4.2 Within the Building Department a specialised purchasing section should be set up. The staffing of this section can be kept to a minimum and it should deal solely with the placing of enquiries, the scheduling of quotations and the placing of subsequent orders, when these have been approved.

7.4.3 All enquiries for materials prices at the estimate stage should be directed by the estimating section through the purchasing section. All requisitions for materials should be prepared by the site agent or by the person in charge of the particular scheme, the quantities and relevance to the specification should be checked in the estimating section and the requisitions so approved

passed forward to the purchasing section for enquiry and subsequent placing of orders. By this means a proper check can be maintained on over-ordering, departure from specification or control of price against the original estimate.

7.4.4 About half the cost of most contracts is for materials. Site management should ensure that wastage on site—breakages, theft and misuse—is kept to a minimum. This can be helped by good site organisation and security, proper supervision, adequate storage arrangements and protection from weather. Care should be taken to see that surplus materials from a completed job on one part of a site are transferred to another where similar materials are to be used. Avoidable breakages may well occur with incentive schemes unless these are properly controlled. Some materials wastage may be difficult to avoid, but no replacements required because of this should be supplied except on a requisition from the site, countersigned by the person in charge of the site, together with a report of the circumstances. Particular care should be taken to prevent theft.

7.4.5 There should be clearly defined arrangements for checking the quantities of materials received on site. All deliveries should be checked and signed for at the point of delivery with a countersignature at the site office after they have been unloaded. Many bulk materials will require periodic test weighs in the case of sand or bulk cement, etc., while spot checks can be made on brick deliveries by counting off individual loads.

7.5 Plant and motor vehicles

7.5.1 The management should continually examine its plant needs to serve current and known future works and choose between the economics of hire and outright purchase. Urgent but short-term requirements should be settled by hiring and it is generally prudent to reserve a proportion of requirements for hire in order to make full use of departmental items already acquired.

7.5.2 The requirements for plant of a general character, such as smaller mixers, dumper trucks, tractors, mobile cranes, excavators and sundry equipment, should be fairly well established and can be financed on a long term basis from an annual contribution to a renewals fund. Items of plant in this group should be charged to jobs on a time basis at hire rates calculated to cover total annual costs, except drivers' and attendants' wages, which are charged directly to the jobs. It is important to keep idle capacity within economic limits and to check departmental machine rates against equivalent hire rates where this is possible. The mechanical plant and sundry builders equipment should be classified in the costing system to identify individual machines; similar items should be grouped to facilitate cost control.

7.5.3 As motor vehicles are employed in a much more mobile capacity than the average site plant the drivers' wages should be included in the running costs of the vehicles which are allocated to the user jobs on the basis of daily timesheet records and hourly rates to cover the full annual costs of the vehicles.

7.5.4 The whole of the costs of operating, both plant and vehicles, including depreciation, replacements and repair, should be fully recovered within the costing arrangements.

7.5.5 Special construction plant, such as tower cranes, batching plants, passenger/material hoists, involves a high capital outlay and is largely

associated with high rise building. There are particular problems in financing its purchase from a fixed annual provision since requirements cannot be known until the jobs have been obtained and are limited to a fairly narrow field of operations. These items should, therefore, be charged directly to the particular jobs at purchase and credited on a valuation basis when taken out of service on the particular job.

7.6 Sub-contractors

7.6.1 If the maximum use is to be made of a Building Department's resources, the use of sub-contractors on its own work should be confined to the specialist field, such as heating and electrical work, lifts, specialist flooring and occasional bulk excavation.

7.6.2 Payments made to any sub-contractors, whether nominated or not, should each be separately coded.

7.7 Oncost and administrative expenses control

7.7.1 Much of labour oncots is governed directly by the number of men employed, e.g. national insurance contributions, superannuation contributions etc., and can be controlled only as part of overall labour control. Particular attention should however be paid to sick pay. Any unduly high sick absences should be reported to the Building Manager. He should also obtain periodic returns from the Treasurer of the cost of sick pay, holiday pay etc., and compare these with the estimates.

7.7.2 The Building Manager should review annually the cost of the Building Department to ensure that operational administrative expenses are fully covered in his estimates and also to satisfy himself of the level of efficiency of his organisation.

Appendix 1

An example of cost control procedures in a larger building department.

Control of Labour Oncost and Overhead Expenses

It is desirable that as far as possible all items of expenditure should be charged directly to the cost centre representing the job concerned. A summary of expenditure items charged in new construction schemes is shown in Note I. There is clearly no problem with direct labour, material from stock, direct material, and so on, which are related to individual jobs through a suitable system of prime documentation. It should be noted that because major works of construction are large, comparatively few in number (10 currently in hand, totalling over £8,000,000), with their own site supervisory and administrative staffs, individual wage payment arrangements, etc., and are virtually self-contained over a fairly long period of time, it is quite practical to charge direct such items as site salaries, social security contributions, travelling expenses, service charges, material handling and the great variety of general building charges associated with establishing and running a large construction scheme.

The same group of expenses and services associated with general maintenance and minor works of adaptation and alteration are spread over more than 100,000 separate jobs a year and as it is obviously impractical to allocate these items directly, they are therefore accumulated under expenditure heads within the labour oncost group and charged to jobs as a percentage rate on direct labour cost. A list of the expenditure heads is contained in Note III and this group relates to maintenance and minor works only.

The remaining group of indirect expenditure is concerned with central administration and establishment charges, depot costs and expenditure relating to employees, such as holiday pay, sick pay, apprentice training, Industrial Safety and Technical Training, Industrial Training Board levy etc. A list of expenditure heads is included in Note IV and it should be kept in mind that these items are considerably summarised in detail as for annual account purposes. This group is again related to individual job cost as a percentage, on direct labour cost, and as a good many of the items involved are common to both maintenance and new construction, the appropriate relationships must be used when calculating the recovery rates.

With regard to both labour oncost and overhead expenditure, it is possible, particularly in an organisation of this size and range, to distinguish different categories of the operational work which participate to a greater or lesser degree in the services and expenditure items represented in indirect expenditure.

It must be said that any decision in respect of differential rates must be soundly based on the evidence as to the facts available within the accountancy system and the particular organisation of works on the principle that cost lies where it is incurred.

Four separate work categories—general maintenance, painting and decorating, minor works and new construction are recognised in this department plus the separate service represented in departmental motor haulage. The appropriate rates are quoted in Notes III and IV.

The department finances capital expenditure on depots by accumulating an annual surplus on revenue account which amounted at the end of the 1967/8 financial year to £135,000. Subject to council authority, about £40,000 per annum will be required over the next five years to finance expected capital expenditure amounting to some £340,000. This item has obviously nothing to do with new construction which is not operated from area depots and is a charge on the maintenance side of the undertaking.

Opinions in respect of the various methods of representing indirect expenditure in job costs vary widely but there is a good deal of virtue in the simplicity of recovery rates calculated on direct labour costs and any so called inaccuracy is often highly theoretical. The recovery rates are examined at the commencement of each accounting year on an estimated basis, and are under continual review during the year.

With regard to control of indirect expenditure, some of the heavier cost items are incurred through central government decisions, local authority regulations and national agreements and have to be carried rather than controlled. The fringe costs of labour in terms of holiday pay, sick pay, social security contributions and selective employment tax amounted to £291,000 or 18% on operational wages during the year 1967/68 and would, of course, have cost very nearly the same absolute amount if the department had worked basic hours only—i.e. the only item to reduce in these circumstances is the graduated pension contribution.

It is a useful exercise continually to review such items as sick pay, depot expenses and head office administration and central establishment charges and it is perhaps worth mentioning that the latter group in the same year amounted to £178,000—4½% on turnover.

Cost and Statistical Statements etc.

The relative efficiency of any building department is a direct reflection of management ability to organise and control the work activities at area and site levels. This is a matter of system, discipline, judgement and the ability to take effective action based on up to date knowledge of the facts.

It is in the field of fact finding that the costing system has a useful part to play by providing detailed information arranged in such a way as to make effective comment on the day to day activities of the organisation.

The system designed must be the tool for the job; one should beware of over-sophistication which leads to confusion and inaccuracy and the complex costings and statistical arrangements which are desirable and workable in an automobile plant operating in a few acres of factory space are neither suitable nor possible for building operations in many thousands of scattered jobs over an area of thirty or forty square miles.

The timing and frequency of routine reports is a matter for management decision but, generally speaking, management is concerned with variances, particularly adverse variances, from planned performance, and a few simple facts at the right time are more effective than a wall full of outdated charts.

It should be emphasised that the accurate compilation of historical cost records during the accountancy periods based on suitably coded prime documentation is quite a different matter from the investigation, criticism and rearrangement of information for management control and for this reason these duties are best performed within a building department by staff who are in close touch with the needs of building management.

The main print-outs prepared by the Treasurer for the management of the organisation are detailed below and any particularly urgent need for information can be filled out by reference to the current flow of documents passing through the head office.

- (i) *Payroll Tabulations*—weekly. This is not discussed in any detail here but useful ancillary information is available since there is a separate pay for each of the area depots and major works with details of bonus payments and so on.
- (ii) *Job Detail Tabulation*—weekly, and including a detailed record of all expenditure for the week only quoting specific prime document references and analysed within the relevant cost centres on the lines laid down for the special cost tabulation.
- (iii) *Job Detail Tabulation*—monthly, for the month only and forms the basis for the accounts rendered. This tabulation is a summarized version of the weekly job detail tabulation.
- (iv) *Direct Charges paid and Direct Charges outstanding*—weekly. Analysed under cost centres, expenditure heads, sundry creditors etc.
- (v) *Stock Ledger*—weekly, showing for each depot detailed records of receipts, issues, opening and closing balances for individual items with all document references for the week concerned. This tabulation is used for stores control, continuous stock audit and a second copy provides each depot with the opportunity to make useful clerical savings by posting weekly summaries on the bin cards.
- (vi) *Construction Labour Tabulation*—weekly. Detailed analysis of labour for each construction job for week only.
- (vii) *Labour Cost Statement*—monthly. Accumulated to date for each major job only—see Note II.
- (viii) *Accounts Rendered*—monthly. Summarized and rearranged version of monthly job detail tabulation for employing committee expenditure analysis and bank transfers.
- (ix) *Financial Ledger*—monthly. Includes monthly and accumulated expenditure, overheads, labour on-cost, plant account, motor haulage account, sundry works account, financial control accounts etc.
- (x) *Special Cost Tabulations*—weekly. This is the most important single tabulation produced for job cost control purposes and the cost of each job included is analysed for the last week and to date as shown in Note V.

The cost centre for each job is the order reference and all works of particular interest are selected for inclusion at head office level. The list obviously includes all major new construction, minor works, all other works carried out against estimates, the schedule maintenance works which can be usefully identified with units of measurement such as renewing gutters, brickwork pointing,

renewing asphalt, cement rendering, etc. and any other jobs of particular significance. It has been mentioned earlier that over 100,000 separate orders a year are concerned with small jobbing repairs at individual properties.

The estimate, prepared in detail, must be regarded as the budget for the job and, in respect of major construction, valuations of the work in progress are prepared at approximately monthly intervals. These valuations should be agreed with and certified by the City Architect or outside quantity surveyor. They form the basis for the job cost/valuation comparison. The nominated items are separately disclosed in cost and the comparisons can be adjusted to bring out the relative costs and values of the builders' work in the work in progress.

Some caution is required in these comparisons, particularly in the early days of the contract, and further analysis may be required to isolate the up to date costs of expensive shuttering and other items which may have been incurred at an early stage and have a 'repeat' value as the work progresses.

The analysed labour costs provide another means of more detailed comparisons if this should be necessary.

When the work is sufficiently advanced and orders have been placed for the bulk of the materials and specialist sub-contractors, the costing staff is in a position to prepare final cost forecasts and put in approximate guide lines on the number of weeks available to completion at current weekly labour costs in order to meet the expected financial outcome. A properly prepared final valuation certified by the architect and building manager at completion of work is the most effective method of demonstrating the real financial outcome of any job. Orthodox final valuations are, of course, expensive to prepare and in well-established and successful building departments some discretion may be exercised in order to limit administrative costs.

Certainly it is in the direct interests of any such department to obtain independent testimony of the value of the work done by proceeding with interim valuations at least until the known final cost has been substantially cleared.

With regard to minor works, which are usually short term, no valuations are taken and weekly cost statements are prepared which bring in the amount of the estimate, the job cost to date including materials delivered to site, and the total value of all orders placed with sub-contractors, to enable management to compare the known progress of the work with the financial margin in hand. Sufficient information is made available in the routine costing records to assist any special costing exercise which may be required and ancillary card records in the departmental cost office which bring together various sources of statistical and cost information in respect of individual jobs form a very useful means of ready reference.

Note I

Summary of expenditure items charged to new construction schemes

1. Operational wages including bonus—analysed as in Note II.
2. Salaries—site and head office.
3. Social security contributions—salaries and wages.
4. Selective employment tax—operational wages and salaries.
5. Superannuation.
6. Defects liability period after practical completion.
7. Materials—Building Department.
—Nominated.
8. Specialist sub-contractors—Building Department.
—Nominated.
9. Haulage—departmental and hired.
10. Plant and equipment—departmental and hired.
11. Site security.
12. Rates.
13. Building water.
14. Temporary services—gas and electricity boards.
15. Telephones.
16. Holiday pay.
17. Sick pay.
18. Retiring allowances—operatives.
19. Apprentices—school fees and day release wages.
20. Construction Industrial Training Board levy, less grant.
21. Industrial safety and technical training.
22. Motor hire and car allowances.
23. Printing and stationery.
24. Insurances—various.
25. Bank Interest.
26. Audit fees.
27. Head office accommodation—rents, rates, services etc.
28. Central administration charges—town clerk, city treasurer, estate surveyor, city architect etc.
29. Progress photography.
30. Sundries—protective clothing etc.

Note II

Construction Labour Cost Statement,
monthly, accumulative

Block	Stage or indirect	Trade or Type	Labour allocation	Hours worked	Cost
			Target Work Non Target Work Bonus Paid	Skilled Unskilled Skilled Unskilled	

<i>Blocks</i>	Various
<i>Stage or Indirect</i>	Substructure Basement Superstructure Labour on Materials General building charges and site administration External Works—paved and grassed areas including paths and roads External Works—fencing retaining walls and boundary walls External Works—random garage blocks External Works—drainage including manholes etc.
<i>Trade or Type of Work</i>	Concretor Bricklayer Carpenter and Joiner Slater and Tiler Plumber and Glazier Plasterer Painter Formwork Steelfixer Scaffolder Drainlayer Pavior Asphalter Labourer—excavation, filling hardcore, grading only—all other labourers charged with trade

<i>Labour Allocation</i>	Erection and removal of temporary hoardings and fences
<i>—General Building Charges etc.</i>	Pumping water from foundations
	Cleaning mud from public highway
	Erection, maintenance and removal site offices etc.
	Offloading and moving materials on site
	Making and erecting signs
	Plant erection etc.
	Temporary service—electricity and gas
	Temporary service—water
	Cleaning out dwellings
	Temporary roads
	Spoil removal
	Foremen, site clerks, hourly paid (supervision and administration)
	Guaranteed week
	Site welfare
	Hoist attendants—standing time only—not to include men on bonus loading out blocks
	Added time
	Expenses
	Watchmen
	Etc.

Note III

Labour Oncost Account: Maintenance and Minor Works Only

Foremen's wages	General maintenance only
Depot duties	General maintenance and limited contribution painting
Haulage charges	General maintenance and limited contribution painting
Social security contributions (wages)	All groups detailed below
Salaries	General maintenance and limited contribution painting, minor works and motor haulage A/C
Social security contributions } (salaries)	
Travelling expenses and tool money	All groups except motor haulage A/C
Small Stores	General maintenance only
Guaranteed week (wages)	All groups detailed below
Sundries	General maintenance only

Recovery Rates 1967/68

General maintenance	37%	Interior decorations vacant houses and trivial
Painting	20%	painting jobs pay general maintenance rate
Minor Works	14%	Pay haulage charges direct
Motor haulage A/C	10%	

Equivalent items in the construction group are charged direct to individual works.

Note IV

Overhead Expenses Account: Maintenance, Minor Works and Construction

Holiday pay	all groups
Sick pay	all groups
Insurances—various	all groups
Retirement pensions—workmen	all groups, limited construction
Apprentice fees and day release	all groups, except motor haulage
Printing and Stationery	all groups, limited construction
Car Allowances	all groups, limited construction
Sundries—medical fees, etc.	all groups
Salaries—head office	all groups
Social security contributions (salaries)	all groups
Superannuation	all groups
Central Establishment charges	
City Treasurer etc.	all groups, limited construction
District Audit fee	all groups
Head office accommodation	all groups
Telephones	all groups, direct construction
Plant, general	all groups, limited motor haulage account, direct construction
Construction Training Board levy	all groups, except motor haulage account
Bank interest	all groups, except motor haulage account
Depot expenses, including stores handling	all groups, except minor works and construction
Industrial safety and technical training	all groups, except motor haulage account
Surplus account	general maintenance and painting only
<i>Income</i>	
Discounts	all groups, direct minor works and construction
Sale of scrap	all groups, except motor haulage, direct construction
Insurance, investment income	all groups
Construction Training Board— grant	all groups, except motor haulage
<i>Recovery Rate</i>	
General maintenance	33%
Painting	33%
Minor Works	26%
Motor haulage account	22.5%
Construction	28% Provisional only—the charges to individual schemes are adjusted annually in accordance with actual cost

Note V

Special Cost Tabulation: weekly

	<i>Cost to date last week</i>	<i>Cost this week</i>	<i>Cost to date this week</i>
<i>Labour</i> —hourly paid			
bonus			
Social security contributions			
Selective Employment Tax			
<i>Materials</i> —ex stock			
—interjob transfers			
Direct deliveries including			
commitments, departmental			
Direct deliveries including			
commitments nominated			
<i>Specialist Sub-contractors</i> —Departmental			
Nominated			
<i>Hired Plant</i> —Machine only			
Machine with driver			
<i>Plant</i> —Departmental			
<i>Hired Haulage</i>			
<i>Departmental Haulage</i>			
<i>Salaries</i> —Site Foreman			
Social security contributions			
Selective Employment Tax			
<i>Salaries</i> —Site Clerks			
Social security contributions			
Selective Employment Tax			
<i>Discounts</i> —direct purchases			
specialist sub-contractors			
<i>Overhead</i>			
<i>Total Cost</i>			
Trade codes for labour and materials—minor works			
Trade codes for materials only—new construction			
Detailed coding in separate statement for labour—new construction			

Appendix II

Programming Techniques

The following notes on the available programming techniques should assist in the selection of the appropriate techniques to suit the situation in hand.

Bar Charts

The bar chart has many uses and will always remain a popular method of setting down the work to be done, but for construction work the bar chart suffers from several disadvantages.

An objective assessment of bar charts will show that:

- (i) The usefulness of the programme depends on the knowledge and experience of the person drawing up the bar chart. Using a bar chart the planner becomes indispensable when the project increases in complexity. Therefore when delays occur it is imperative that the planner is responsible for updating, as only he knows the time sequence of jobs or their true dependency on each other.
- (ii) Each job or task is shown in isolation and inter-relationships are not given.
- (iii) It is extremely difficult to revise the programmes quickly.
- (iv) It will not show if a certain task is critical to the programme.

Recent planning techniques have been developed which will over-come these disadvantages. Two of these, network analysis and line-of-balance, which are more suitable for construction programming, are described.

Network Analysis

For most construction projects network analysis has proved to be the most comprehensive planning technique.

The basis of the technique is the diagrammatic representation of the work programme for a project in flow process chart where each operation (activities, jobs, tasks) is depicted by an arrow line. The arrow diagram is drawn in such a way to show the logical way for any project to be constructed together with an indication of the inter-relationship of each activity.

Network analysis, therefore, involves breaking down each project into separate activities and the network diagram links these activities logically to show which jobs can go on in parallel and which must await the completion of previous activities.

Duration times are next added to each activity. These durations can be derived from experience of productivity achieved or initially on a best guess basis. As duration times are dependent on the labour and plant to be employed it is a useful aid to note these facts against each activity at the same time.

From these duration times it is possible to calculate the minimum length of time in which the whole job can be completed. This is done by adding together the time of sequential activities; where there are alternative sequences,

the longest of the sequences is used to calculate the total project time. Those activities on which this time primarily depends constitute the "critical path".

Any delay to the critical path activities will prolong the completion of the project and attention must always be focussed on the actual progress of these activities.

By assigning resources to each activity an aggregation can be given, on a weekly or monthly basis, of the peaks and troughs in the demand for labour and plant. Those activities on the critical path must be given priority of resources but if the peaks and troughs are too abrupt, then the non critical activities can be re-scheduled, within certain time limits, to level or smooth out the demand for resources in short supply.

Once decisions have been made about the best way to deploy resources, detailed working schedules can be produced for all concerned giving them starting and finishing dates for the activities which are their responsibility.

Network analysis can provide:

Early and logical planning of the whole project.

A means of showing the full inter-relationship of all activities.

A control procedure to monitor progress against the agreed programme.

A typical network for the construction of a single house, together with an illustration for the calculation of the critical path, is shown in Fig. 1.

It is to be emphasised that all members of supervision (preferably down to foreman level) should be trained to understand the use of network analysis. It has however been found in practice that to control progress by a network at site level is seldom satisfactory and that for quick easy reference it is essential that the networks are translated into short term programmes in bar chart form. An example of this presentation is shown in Fig. 2.

Line-of-Balance

Network analysis has proved an extremely satisfactory planning technique for the one off or unique project; but for work containing a high degree of repetition a new but simple technique called Line-of-Balance can be recommended.

Line-of-Balance was originally developed for planning and controlling mass production processes in factories by determining the resources (people and machines) and speed for each stage of manufacture so that a required rate of output can be reached. Because different operations take different lengths of time, each stage of production is arranged to provide a reservoir or "buffer" stock of articles so that succeeding operations are not held up. Thus a production plan using optimum resources can be formulated against which actual production can be gauged.

Repetitive construction, such as building a number of similar houses, has much in common with factory production. The only difference is that in a factory the products move along a line while the operatives are stationary, whereas in building the products, in this case houses, are stationary and the operatives move along the line.

To build houses at a set rate the labour strength and speed of working of each trade or activity have to be estimated separately. A margin of error between estimate and achievement must be allowed for and to avoid such errors interfering with the programme of work, buffers are provided between succeeding activities. Unlike factory production, however, the buffers used are units of time and not products.

The results so far have shown that when line-of-balance has been applied to housing contracts containing repetition, substantial increases in productivity through the optimum use of labour are made. It has also shown that the techniques are simple and readily understood by all staff at both site and management level.

Line-of-balance schedules are a series of inclined bar-lines, one for each trade. The big difference between line of balance schedules and a traditional bar chart is that the schedules are inclined at different slopes to denote the rate of working of the various trades; they thus display the relationship of manning and speed of working of one trade against another, highlighting the risk of collision course and unbalanced manning. Schedules can also be used to programme plant utilisation and materials delivery.

Line-of-balance can be used initially to produce alternative construction plans which will determine the most economic contract period by considering:

- (i) The number of gangs required in different trades which will work in rhythm with each other in such a way to reduce unproductive or waiting time to a minimum.
- (ii) The overall construction period of least cost which will not exceed the required contract time.

Fig. 3 shows in simplified form a line-of-balance schedule for the construction of 7 houses. It will be seen that 45 days will elapse before the first handover and if the complete job is required in 75 days then progress must be made at the rate of 1 house per 5 days. Also shown is the arrangement of gangs to create the most economical use of labour to meet the desired rate of progress.

Fig. 4 shows a more realistic example for line-of-balance scheduling and covers a 220 house contract. It can be seen that glazing is manned with 6 men up to house 110 and thereafter with 4 men, resulting in the kinked schedule for that trade.

For a detailed explanation of the techniques briefly described, reference can be made to the following publications:

- (i) *Project Co-ordination. The pre-contract planning and control of building work programmes.* N.B.A.
- (ii) *C.P.M. in Construction Management.* J. J. O'Brien. McGraw-Hill.
- (iii) *Programming House Building by Line-of Balance.* N.B.A.

Painter External

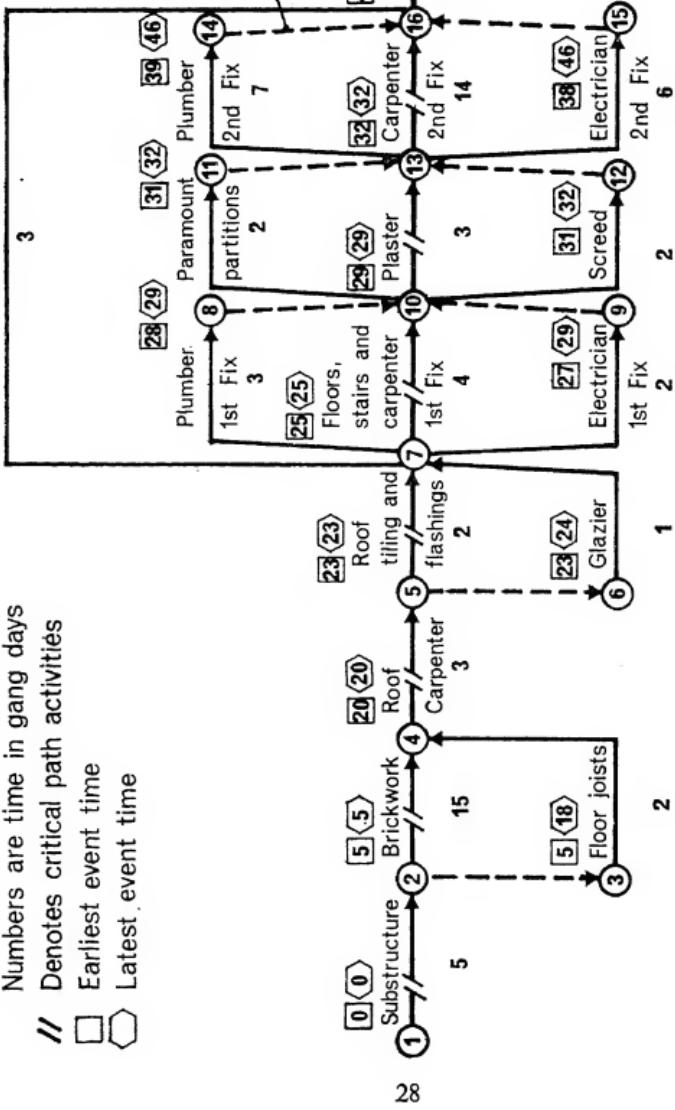


Fig 1 Typical network programme for building a house

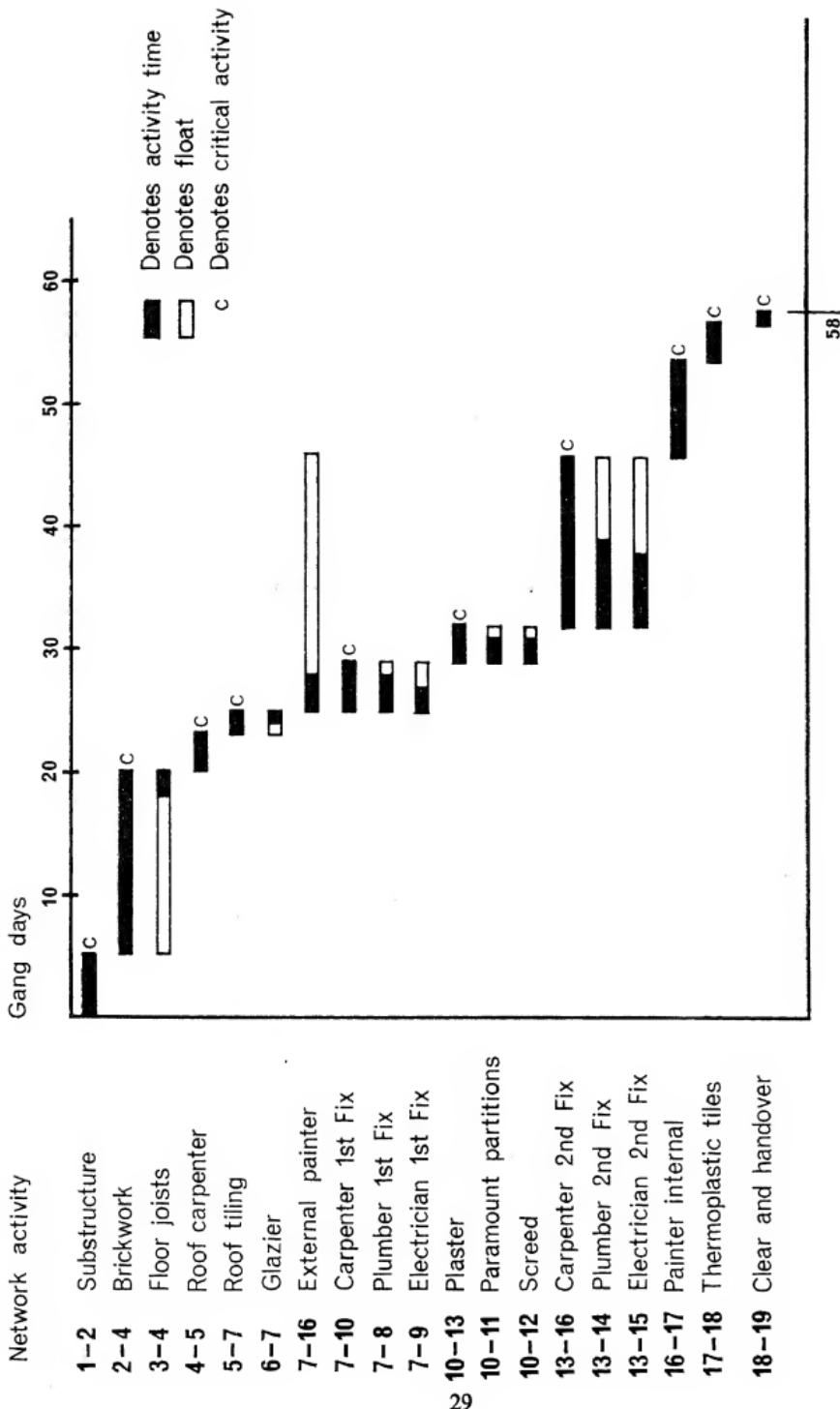
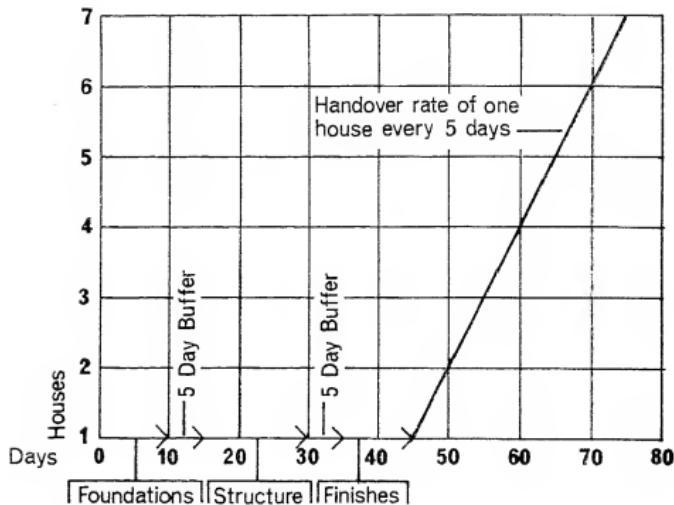
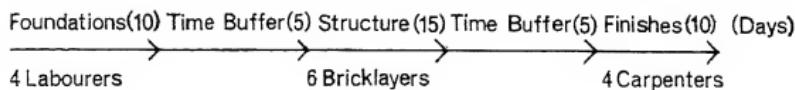


Fig 2 Bar chart representation of network showing float

(a) Construction rate for 7 houses



(b) Time and Labour estimates



(c) Line-of-Balance schedule

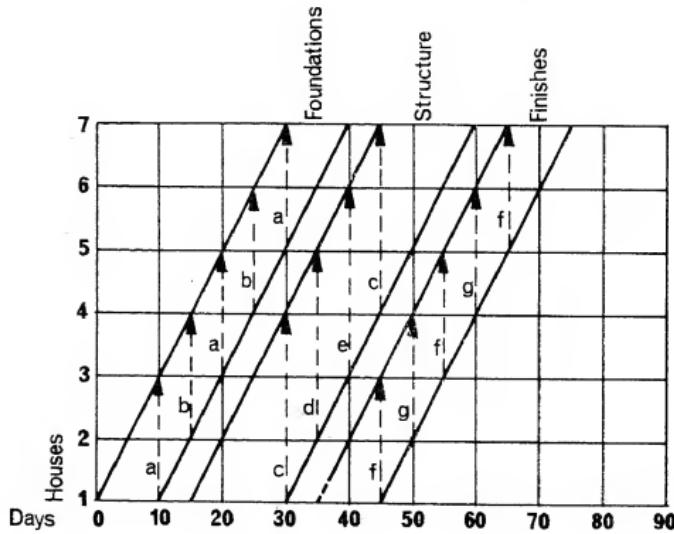
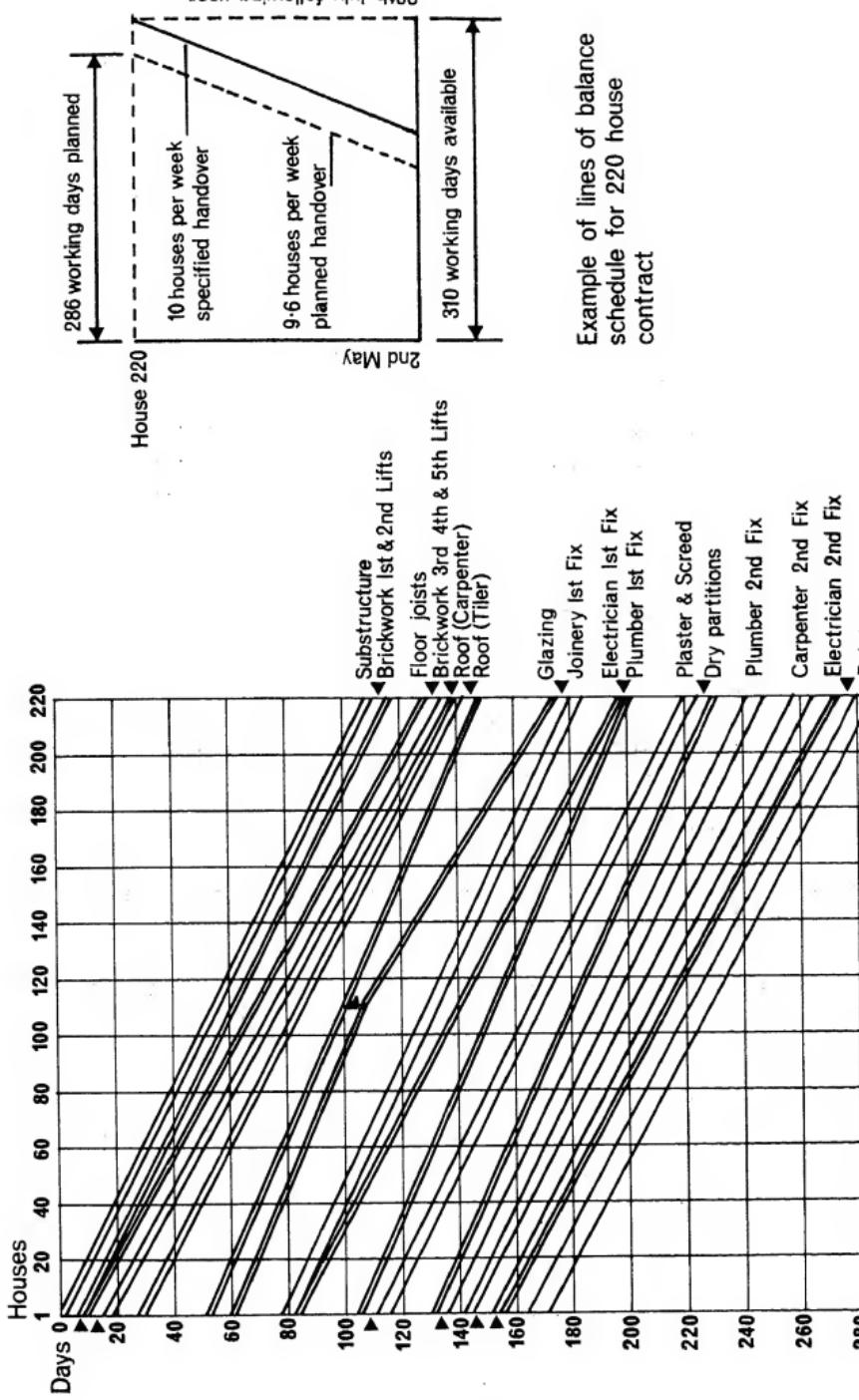


Fig 3 Example of Line-of-Balance schedule for 7 houses

Fig 4

Positions at which n buffers effective shown or



Appendix III

Definitions

In this manual, the terms "*underspending*" and "*overspending*" are used to denote the difference between the quantity surveyor's valuation of the work done and the cost incurred by the Building Department in doing the work.

The terms "*saving*" and "*loss*" are used to denote the difference between the Building Department's costs and the estimated amount which would have been payable to the lowest tendering contractor.

A Building Department scheme may be overspent and yet show a saving as compared with what would have been payable to the lowest tendering contractor. Assume, for example, the following facts:

	£
(i) Building Department's tender	100,000
(ii) Lowest tendering contractor's tender	106,000
(iii) Building Department's final cost	117,000
(iv) Quantity surveyor's final valuation of work done	113,000

then:

- (a) the Building Department's *overspending* is £4,000 (£117,000 less £113,000); and
- (b) the Building Department's *saving* is approximately £2,000, calculated thus:

	£
Building Department's saving at tender stage (i.e. £106,000 less £100,000)	6,000
<i>Less:</i> Overspending, as at (a) above	4,000
 Savings to the Council	 <hr/>
	2,000

The term "*interim cost/value comparison*" denotes a statement comparing the actual cost to date with the quantity surveyor's valuation of work done to date.

Sub-contractors employed by the Building Department fall into two groups: "*nominated sub-contractors*", who are employed by the Building Department at the direction of the architect; and "*voluntary sub-contractors*", who are employed by the Building Department (at the Building Manager's discretion) to do work for which the Building Department is directly responsible.

Indirect charges and overheads can be classified in many ways. The classification used in the manual is as follows:

Labour oncosts consist of expenditure which it is convenient to allocate on the same basis as wages, e.g.

national insurance contributions (including contributions to the Redundancy Payments Act Fund)

graduated pensions contributions

superannuation contributions

sick pay
holiday pay
tool money
training (including the Construction Industry Training Board levy)
inclement weather payments
protective clothing
third party and employers' liability insurance
selective employment tax
redundancy payments not recovered from Redundancy Payment Act Fund.

Stores oncosts include cost of handling materials issued from stores. (Materials are generally delivered direct to site and materials oncost is, therefore, not normally an important element in construction costs.)

Operational administrative expenses include the cost of the salaries, accommodation, office expenses, etc. of the building manager's department—technical, administrative and clerical.

Central administrative expenses include the cost of the salaries, accommodation, office expenses, etc. of central departments, e.g. Clerk's and Treasurer's departments.

Salaries and expenses of site agents, general foremen, bonus clerks, site clerks, checking clerks, etc. are treated in various ways—as part of labour oncosts or operational administrative expenses, or allocated direct to the scheme or partly on one basis and partly on another.

Appendix IV

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